THE CHROMOSOMES OF TWO SPECIES OF NORTH AMERICAN TETTIGONIIDS (ORTHOPTERA – TETTIGONIOIDEA)[1, 2]

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ABSTRACT: *Dichopetala brevihastata* (Phaneropteridae) has the karyotype 2n (♂) = 23, including a "giant" pair of autosomes. This chromosome number has not previously been observed in the family. *Eremopedes ephippiata* (Tettigoniidae) has the karyotype 2n (♂) = 31, the modal number for the family. Both species have an XO (♂) – XX (♀) sex-determining mechanism.

DESCRIPTORS: *Dichopetala brevihastata:* karyotype; records. *Eremopedes ephippiata:* karyotype; records. Tettigonioidea: karyotypes, survey of.

The species of the superfamily Tettigonioidea are common insects, and the group is represented in the recent fauna by about 1120 genera and over 7000 species. The literature on the cytology of the tettigonioids is, however, very limited, and deals with only about 1.5% of the species. The pioneer works on the subject are those of McClung (1902, 1905, 1914, 1917), Woolsey (1915), Winiwarter (1931), Ohmachi (1935), Hareyama (1932), Asana (1941), Asana et al. (1938), Matthey (1948), and Piza (1950, 1953, 1958). More recently a few additional papers have been published, by Henderson (1961), Dave (1965), White et al. (1967), and Ferreira (1969, 1973, 1976a, b).

The data thus far obtained show that this group of insects is characterized by a wide range of variation in the chromosome number. This situation agrees with the taxonomists' concept of the Tettigonioidea being an ancient and very diversified group. The great majority of the studied species have males with an XO (♂) sex mechanism, the X being either acrocentric or metacentric and always heteropycnotic during the first prophase, its size being rather variable among the species. Thus far six species are known to have changed their primitive XO (♂) – XX (♀) sex mechanism to a more complex one (Dave, 1965; White et al., 1967; Ferreira, 1969, 1976a). In the present paper we deal with the chromosomes of two species belonging to different genera of which no members have hitherto been cytologically examined.

Material and Methods. The specimens studied were collected at the following localities in Cochise Co., Arizona, U.S.A. by A. Mesa and T.J. and

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J. Cohn, and have been deposited in the Museum of Zoology of the University of Michigan.

Phaneropteridae

Dichopetala brevihastata Morse.

4 ♂♂, Bisbee Jct., 4 mi. S. of Warren, alt. 4,700 ft., 22 Aug., 1973 (Cohn-Mesa Field No. 23; Slide Nos. 4951-3).

Tettigoniidae: Decticinae

Eremopedes ephippiata (Scudder)

1 ♂, Don Luis, 0.3 mi. W. of Naco Road Jct., alt. 5,020 ft., 22 Aug., 1973 (Cohn-Mesa Field No. 21; Slide No. 4954).

2 ♂♂, Huachuca Mts., road summit above Carr Canyon, 7.8 road mi. SW. of Fletcher's at jct. with Hwy. 92, alt. 7,400 ft., 22-23 Aug., 1973 (Cohn-Mesa Field No. 25; Slide Nos. 4955-6).

All the testes were fixed in a mixture of 100% ethyl alcohol and acetic acid (3:1). The squash preparations of the chromosomes were stained with acetic orcein (2%), and the photographs taken with a Zeiss photomicroscope.

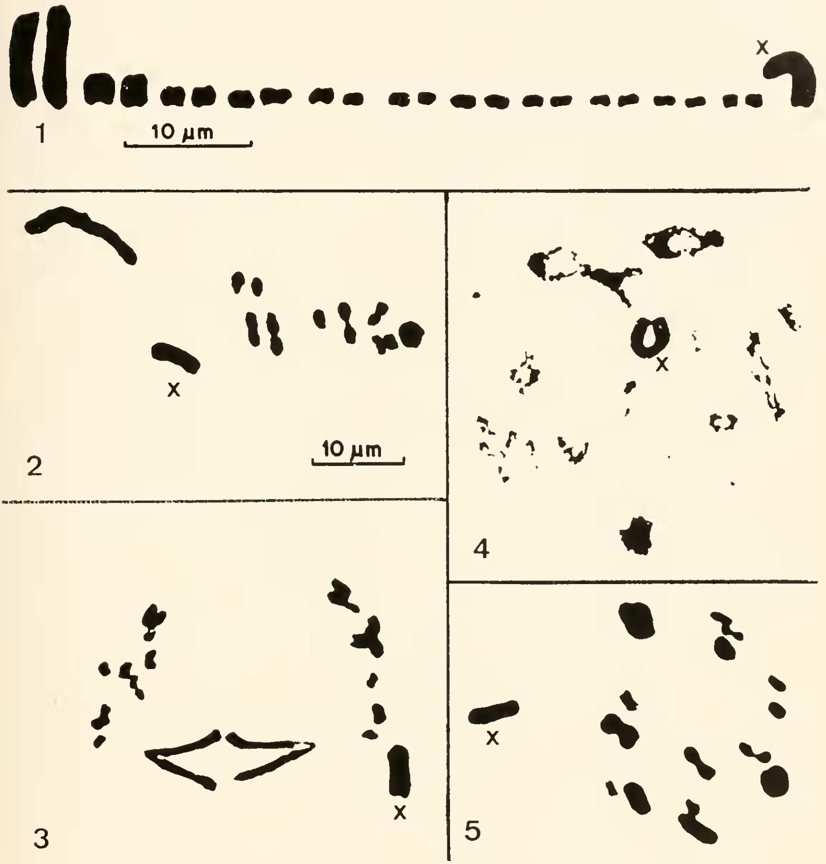
Results

Dichopetala brevihastata. The chromosome number of this species is 2n (♂) = 23 and the sex mechanism is of the XO (♂) – XX (♀) type. All the chromosomes are acrocentric. The autosomes are organized into one huge pair, another medium-sized one, and nine pairs of small chromosomes (figs. 1 and 2). The giant bivalent, which contains nearly one-half (≅ 7/15) of the autosomal chromatin, shows only one or two chiasmata and always has a delayed segregation during the first anaphase (fig.3). The medium-sized bivalent also shows one or two chiasmata, while the remaining pairs have only one chiasma per bivalent.

Eremopedes ephippiata. This species has 2n (♂) = 31 acrocentric chromosomes and a sex mechanism of the XO (♂) – XX (♀) type. During the first prophase fifteen bivalents besides the unpaired X are seen (fig. 4). The fifteen autosome pairs show a gradual decrease in size from largest to smallest, making their grouping difficult (fig. 5). The largest pairs have two or three chiasmata, while the remainder have a single chiasma which may be interstitial or terminal. No asynchronized movement of the chromosomes to the pole was observed. The sex chromosome is the largest of the set, and is always heteropycnotic during first prophase.

Discussion

Among the tettigoniids the widest range in chromosome number is found in the family Phaneropteridae, in which the lowest and highest numbers as yet known are 2n (♂) = 16 and 2n (♂) = 39 (Ferreira, 1973, 1976a, b). Species with 2n (♂) = 33, 31, 29, 27, 25, 21 and 16 have been reported by several



Dichopetala brevihastata. Fig. 1. Spermatogonial metaphase, with chromosome pairs arranged according to size.

Fig. 2. First metaphase.

Fig. 3. First anaphase.

Eremopedes ephippiata. Fig. 4. Diplotene.

Fig. 5. First metaphase.

authors. According to Ferreira (1967a,b) the commonest karyotype among phaneropterids is 2n (♂) = 31, with all the chromosomes acrocentric. The usual sex mechanism is of the XO (♂) – XX (♀) type. Five species of the family are known to have a more complex sex system (Dave, 1965; White et al., 1967; Ferreira, 1969, 1973, 1976a). Many chromosomal rearrangements must have occurred during the evolution of the family to account for the present karyotypic diversity (Ferreira, 1976b).

Dichopetala brevihastata is the first phaneropterid with 2n (♂) = 23 acrocentric chromosomes to be reported. The oddity of chromosome size-grouping observed in it is due to the occurrence of a "giant" chromosome pair. A series of translocations and inversions concentrated nearly half of the autosomal chromatin in a single chromosome. The presence of such a "giant" chromosome is unusual in the family, but a similar situation was found by Ferreira (1969) in the Australian *Tinzeda albosignata,* which has a "derived" karyotype with 2n (♂) = 25 acrocentric chromosomes and shows a sharp bimodality of chromosome size. In both it and *D. brevihastata* the asynchronized behavior of the "giant" autosomes during anaphase is a consequence of the sharp difference in size among the autosomes.

The subfamily Decticinae is, together with the Tettigoniinae and Saginae, the most primitive among the living tettigoniids with developed wings (Sharov, 1968). The karyotype found in *Eremopedes ephippiata,* with 2n (♂) = 31 acrocentric chromosomes, is the one commonest among the Decticinae, which exhibit a remarkably constant chromosome set among their species (Mohr, 1916; Buchner, 1909; Winiwarter, 1931; Hareyama, 1932; Ohmachi, 1935; Henderson, 1961; White, 1941). There are, however, some notable exceptions in *Atlanticus pachymerus* (White, 1941), *Lanciana albidicornis* (Ferreira, 1969) and *Anabrus simplex* (McClung, 1902, 1905, 1914). In the first two of these 2n (♂) = 25 occurs; in *A. pachymerus* the X chromosome and four autosomes are submetacentric, while in *L. albidicornis* all the chromosomes are acrocentric. In *Anabrus simplex* McClung found 2n (♂) = 33 and a sex mechanism of the XO (♂) – XX (♀) type. On the basis of McClung's description and drawings, however, White et al. (1967) suggested that *Anabrus simplex* has a neo-XY (♂) sex system, making the further study of its karyotype desirable.

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LITERATURE CITED

Asana, J.J., S. Makino and H. Niiyama. 1938. A chromosomal survey of some Indian insects. I. Morphology of the chromosomes in eight species of the Locustidae. J. Fac. Sci. Hokkaido Univ. Serv., 6: 221-234.

Asana, J.J. 1941. Chromosomes of *Typhoptera donovani.* Indian Academy of Sciences, 12: 47-49.

Buchner, P. 1909. Das accessorische Chromosomen in Spermatogenese und Ovogenese der Orthopteren, zugleich ein Beitrag zur Kenntnis der Reduktion. Arch. f. Zellfrsch. Bd. 3.

Dave, M.J. 1965. On unusual sex chromosomes found in two species of the Locustidae. Cytologia, 30: 194-200.

Essig, E.O. 1947. College Entomology. pp. 1-900. MacMillan Co., New York.

Ferreira, A. 1969. Chromosome survey of some Australian Tettigoniids (Orthoptera – Tettigonioidea): Two species with neo-XY sex-determining mechanism. Cytologia, 34(4): 511-522.

________. 1973. Estudos citogenéticos nas super-familias Acridoidea e Tettigonioidea (Orthoptera). Tese de Livre Docência, Faculdade de Filosofia, Ciências e Letras de Rio Claro, Brasil, 182 pp.

________. 1976a. Cytology of Brazilian Phaneropteridae (Orthoptera-Tettigonioidea): A species with Neo-XY sex determining mechanism. Canadian Journal of Genetics and Cytology. (In Press).

________. 1976b. Cytology of Neotropical Phaneropteridae. (In Press). Genética.

Hareyama, S. 1932. On the spermatogenesis of an orthopteran, *Gampsocleis burgeri.* D.H. Jour. Sci. Hiroshima Univ. Serv. B, Div. l. Vol. 1.

Henderson, S.A. 1961. Chromosome number and behaviour in the grasshopper *Pholidoptera.* Heredity, 16: 181-186.

Matthey, R. 1948. Donnés nouvelles sur les chromosomes des Tettigonides et la parthénogénèse de *Saga pedo* Pallas. Rev. Suisse Zool., 55: 45-56.

McClung, C. 1902. The spermatocyte divisions of the Locustidae. Kansas State Univ. Sci. Bull., 1: 185-231.

________. 1905. The chromosome complex of orthopteran spermatocytes. Biol. Bull. (Woods Hole, Mass.), 9: 304-340.

________. 1914. A comparative study of the chromosomes in orthopteran spermatogenesis. J. Morphol., 25: 651-749.

________. 1917. The multiple chromosomes of *Hesperotettix* and *Mermiria.* J. Morphol., 29: 519-589.

Mohr, O.L. 1916. Studien über die Chromatinreifung der männlicher Geschlechtszellen bei *Locusta viridissima.* Arch. Biol. Paris, 29: 579-752.

Ohmachi, F. 1935. The relation between chromosomes and classification in the Grylloidea. Dobutsugaku Zasshi, 217: 593-605.

Piza, S.T. 1950. Breve noticia acerca dos cromossomios de *Ischyra punctinervis* Brunner e *Phylophyllia guttulata* Stäl (Orthoptera-Phaneropteridae). Folia Clinica et Biologica, 16(2): 72-73.

________. 1953. A note on a pair of giant autosomes in *Agraecia rubulata* (Redt) Orthoptera-Agraeciidae. Atti del Congresso Internazionale de Genetica. Caryologia, 6: 778-779.

________. 1958. A short notice on the chromosomes of *Phlugis* (Orthoptera-Listroscelinae). Rev. Agr. (Piracicaba, Brasil), 330(2): 72-73.

Sharov, A.G. 1971. Phylogeny of the Orthopteroidea. Published for the Smithsonian Institution and the National Science Foundation, Washington, D.C. by the Israel Program for Scientific Translations. 118: 251 pp.

White, M.J.D. 1941. The evolution of the sex chromosomes. II. The X chromosome in the Tettigoniidae and Acrididae and the principle of "evolutionary isolation" of the X. J. Genet., 42: 173-190.

White, M.J.D., A. Mesa and R. Mesa. 1967. Neo-XY sex chromosome mechanism in two species of Tettigonioidea (Orthoptera). Cytologia, 32: 190-199.

Winiwarter, H.de. 1931. Evolution de l'heterochromosome chez *Tettigonia (Decticus) albifrons* (Fab.). Arch. Biol., Paris, 42: 201-228.

Woolsey, I.C. 1915. Linkage of chromosomes correlated with reduction in numbers among the species of a genus; also within a species of the Locustidae. Biol. Bull. (Woods Hole, Mass.), 4: 163-187.